

WATER MANAGEMENT IN THE KŁODNICA CATCHMENT IN 2000-2010

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Abstract. The article takes up an attempt to present the changes that has occurred in the water management at the beginning of the 21st century in the area of Silesian Voivoideship. Communes situated within the boundaries of Klodnica catchment, closed by the section of Gliwice, were analysed as an example of water management in the area which undergoes a strong anthropopression. Klodnica catchment is an area where all the elements of the geographical environment were transformed, but it was the water environment that was changed most visibly. At the beginning of the 21st century, there were a lot of changes conducted in Poland, not only political, but also in the economic and legal sectors. Owing to these factors, the following changes appeared: water consumption, the structure of distribution of water among different branches of economy and the water and sewage system infrastructure. The effect of these changes is the decrease in water consumption and sewage discharge as well as upgrading the technologies of its treatment (Absalon 2007).

Keywords: Water management, Silesian Voivoideship, Klodnica catchment, anthropopression

Introduction

Water management is a branch of national economy which is subject to changes in time and space. It is influenced by the political situation, governments changes as well as external and internal economic situation (Absalon 2007). The aim of water management is to examine the methods of the use of water supplies, furnishing people with water, protection of waters from pollution, its treating and monitoring (Węglarczyk 2006).

Water is one of the most important components of the natural environment, essential for living and economic activity of man. Silesian Voivoideship is a relatively water-deficient area and therefore a proper water management and a balanced water and sewage management systems are priorities for the region (Panasiuk *et al.* 2011).

The development of economy in Upper Silesia and its surrounding areas is connected mainly with the concentration of mineral resources, with the subsequent development of technical infrastructure enabling and supporting exploitation and with the progressive process of urbanization (Runge and Zadrozny 1989; Trochim 2006).

Industrial activity, manifesting itself in the exploitation of fossils, implicates multidimensional changes in the natural environment of mine-fields. These changes are best illustrated in the transformations of water

rates both of surface and ground waters (Jankowski and Kuczera 1991).

Anthropopression in a catchment area is a factor which can influence the water rates directly, by water abstraction and water discharge, piping away the mining wastewaters, water transfers within river basins, drainage and an intensive exploitation of ground waters, and indirectly, by agro-technical interventions, melioration, hydro-technical development of watercourse beds, building retention reservoirs, urbanization of an area and essential changes in land use management (Jankowski and Kuczera 1991).

Study area

Upper Silesia is situated in the upper river basin of Odra and Mala Wisla (fig 1A). Klodnica is a right-bank river basin of Odra. Its length until the water gauge cut in Gliwice is 44,7 km. The springs of Klodnica are situated on the Katowice Upland in the southern part of Katowice – in Murckowskie Forests at 305 m ASL. The river flows through following districts: Ligota and Panewniki in Katowice, Klodnica and Halemba in Ruda Slaska, along the southern boundary of Zabrze and Gieraltowice, through Gliwice and farther west. Klodnica also supplies Dzierzno Duze water reservoir (fig 1B) (Ruman *et al.* 2006). Klodnica catchment is void of any natural water reservoirs and the existing catchments were created as a result of man's activities.

The biggest catchment is Dzierzno Duze with the capacity of 10 mln m³ (Dulias and Hibszer 2004).

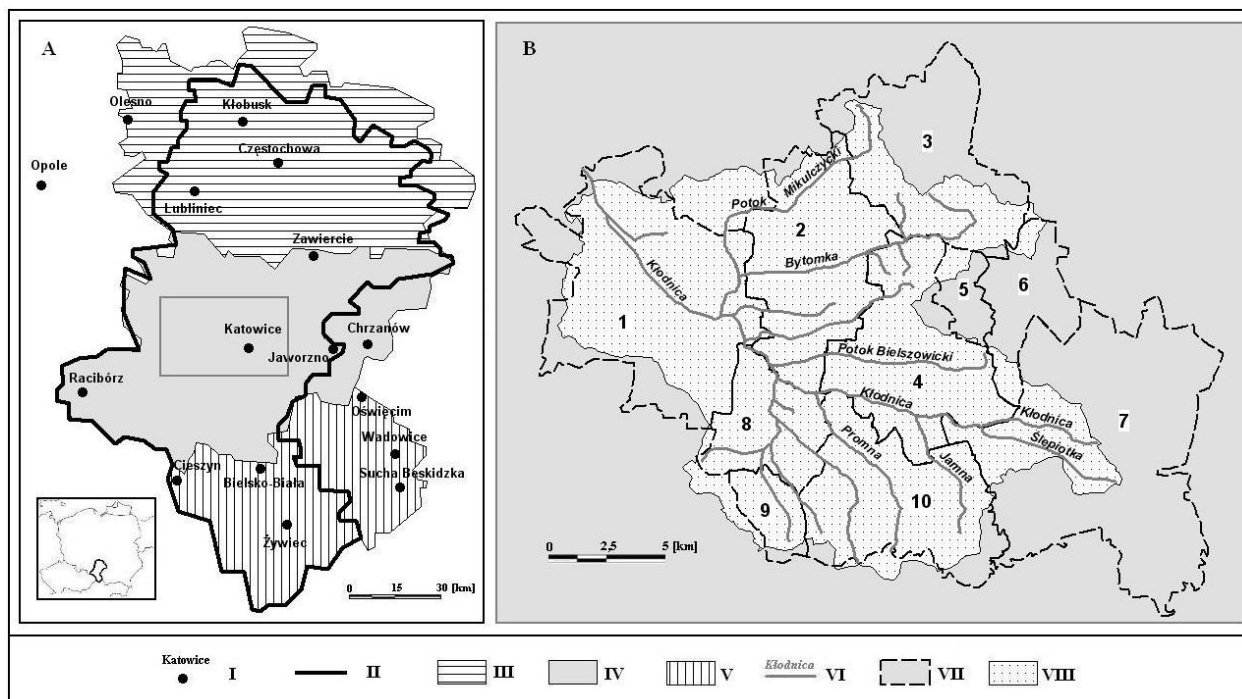


Fig 1. The localization of the area of research (A) and Klodnica catchment (B)

I – cities; II – administrative boundaries of Silesian Voivodeship; III – boundaries of the former Czestochowa Voivodeship; IV – boundaries of the former Katowice Voivodeship; V – boundaries of the former Bielsko-Biala Voivodeship (in the years 1975-1998); VI – watercourses; VII – the area of communes: 1 – Gliwice, 2 – Zabrze, 3 – Bytom, 4 – Ruda Śląska, 5 – Swietochłowice, 6 – Chorzów, 7 – Katowice, 8 – Gieraltowice, 9 – Ornontowice, 10 – Mikolow; VIII – the area of Klodnica catchment until the Gliwice cut (map mine)

However, it is situated outside the boundaries of the analyzed part of Klodnica catchment. Klodnica has got quite a densely developed net of influxes. There are 24 right-bank influxes and 16 left-bank influxes in the analyzed area. Among the right-bank influxes there are Potok Bielszowicki, Czerniawka, Potok Sosnicki, Bytomka and among the left-bank influxes there are Slepotka, Jamna, Promna and Potok Gieraltowicki.

In the central part of Silesian Voivodeship there is a highly developed industry, mainly coal mining and coal processing. Up to the present day there are several coal mines, coking plants, thermal power stations and steelworks working. Nowadays, in the area of Katowice conurbation there are other branches of economy and services developing. A large number of sewage farms operating in the area of Klodnica catchment contributes to the improvement of the cleanness of rivers. On the other hand, the population density of this area, which is the highest in Poland and one of the highest in Europe, contributes unfavorably to the irreversible changes in the environment (Chmura 1985; Rzętała 2000).

Klodnica catchment is a characteristic example of the influence of anthropopression on water environment. Within its boundaries there took place a serious disturbance of water rates manifesting itself, among other things, by anthropogenization of the outflow,

the transformation of the surface hydrographic net configuration and degradation of the quality of ground waters eliminating the possibility to self-decontamination (Chmura 1985; Rzętała 2000).

Methodology

This work is an attempt to analyze the changes which took place in the water management at the beginning of the 21st century in the area of Silesian Voivodeship and the communes situated in Klodnica catchment closed by the water gauge cut in Gliwice in the years 2000-2010. The data from this period were compared with the records from 1990. To evaluate these changes, data presented in biennial intervals were used. The compared data come from the periods during which two different administrative divisions were functioning. In the year 1990 there was an administrative division valid between 1975-1998 when there were three separate voivodeships in the area of the present-day Silesian Voivodeship : Katowice Voivodeship (6650 km², 3,89 mln of population), Bielsko-Biala Voivodeship (3704 km², 927 000 of population) and Czestochowa Voivodeship (6182 km², 779 000 of population) (the data come from 1998).

The period of 2000 - 2010 is the currently valid administrative division (fig 1B). In 1990 the area of Katowice Voivodeship constituted 54% of the area of present Silesian Voivodeship (12294 km²) which was taken into account during the data analysis.

The analyzed Klodnica catchment is situated within the administrative boundaries of the following cities: Katowice, Gliwice, Bytom, Zabrze, Ruda Slaska, Chorzow and communes: Mikołow, Gieraltowice, Ormontowice and urban powiat Swietochlowice (fig 1B). Ormontowice was created in 1991 from a part of Gieraltowice.

With the aid of MapInfo program, the area of the communes in Klodnica catchment was calculated (table 1). The factors were presented in percents and hence, the data relating to communes and poviats received from the Voivodeship Statistical Office in Katowice were calculated so as to get the most reliable analysis of the results. Only the communes which proportion constitutes a essential part of Klodnica catchment were analyzed. In the table they are presented in bold.

Table 1. Communes and poviats situated in the area of Klodnica catchment.

City / commune	Status of the city / commune	area [km ²]	The area encompassed by the catchment	
			[km ²]	[%]
Katowice	City county	164,64	39,52	24
Gliwice	City county	134,2	102,0	76
Bytom	miasto na prawach powiatu	96,43	30,55	44
Zabrze	City county	80,4	77,18	96
Mikołow	Urban commune	79,2	76,03	96
Ruda Slaska	City county	77,73	74,62	96
Gieraltowice	Rural commune (Gliwice powiat)	39	38,22	98
Chorzow	City county	33,5	6,53	19,5
Ormontowice	Rural commune (Mikołow powiat)	15,1	13,6	90
Świetochlowice	Rural commune (Chorzow powiat)	7,6	1,75	22,5

Water resources, their use and pollution and protection of Silesian Voivodeship waters

The water resources of Silesian Voivodeship show a wide variety, which is a result of the diversification of the geographical environment. The changeability of the outflow is significantly higher than the changeability of precipitation. The proportion of anthropogenic outflow, which means the extraneous waters in the overall outflow in the area of the voivodeship is very high and reaches up to 85% in the case of Rawa river (Galiński *et.al.* 2005).

The bid for water is caused mainly by the needs of economy, while the deciding factor of the quantity of water resources is the precipitation (Mikulski 1998).

In the years 2000 – 2010 the maximum sum of precipitation was recorded in 2010, while the lowest one in 2003 (fig 2). It should also be highlighted that the quantity of precipitation in the area of Katowice Voivodeship in 1990 was the same as in 2008 in the area of Silesian Voivodeship.

The use of water resources depends on many factors, such as population, the level of economy development, technological advancement, ecological awareness of the society (Absalon 2007).

During the analyzed period, there was a 4,36% decrease in the population of Silesian Voivodeship (fig 3).

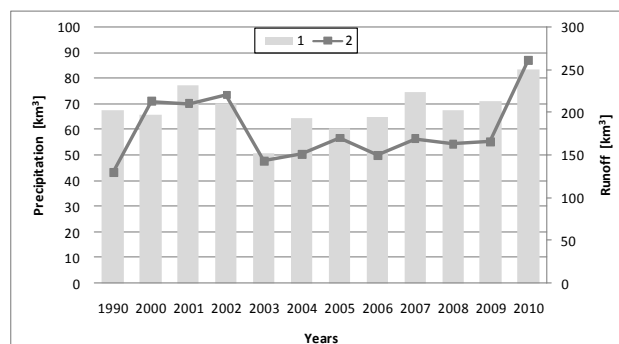


Fig 2. Water resources of Katowice Voivodeship (1990) and Silesian Voivodeship in the years 2000 – 2010 1 – precipitation, 2 – outflows (worked out by me on the basis of data from the Central Statistical Office)

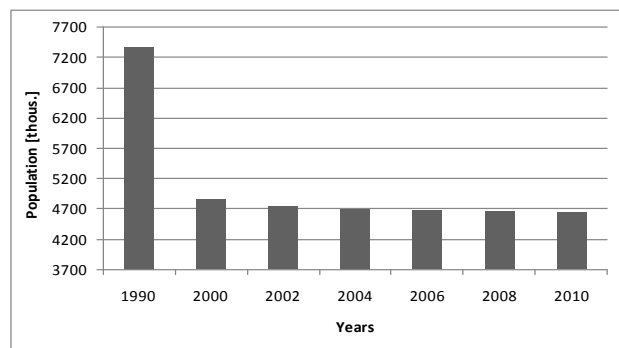


Fig 3. Population of Katowice Voivodeship (1990) and Silesian Voivodeship in the years 2000 – 2010 (worked out by me on the basis of data from the Central Statistical Office)

In the years 2000 – 2010, water intake for the needs of national economy and population decreased from 11048,6 hm³ in 2000 to 10866,4 hm³ in 2010 (fig 4).

As compared to 1990, there was a 22% decrease in water intake in the year 2000. The maximum water intake at the beginning of the 21st century was recorded in 2006. The increase was caused by higher water intake for production (9.8 hm³ more than in the preceding year).

Water use for the needs of national economy and population in 2010 amounted to 400,7 hm³ (3,9% of the national use) and was 26% smaller in comparison to the year 2000 (fig 5). In 1990, the water use amounted only to 312,2 hm³. Among 119 Polish cities with the

highest water use there were 28 cities from the Silesian Voivodeship, including all the city counties, except Swietochlowice and Zory. Since the year 2000, a systematic decrease in the quantity of the use of water from the waterworks can be observed. It shows that the parsimony in water management has increased.

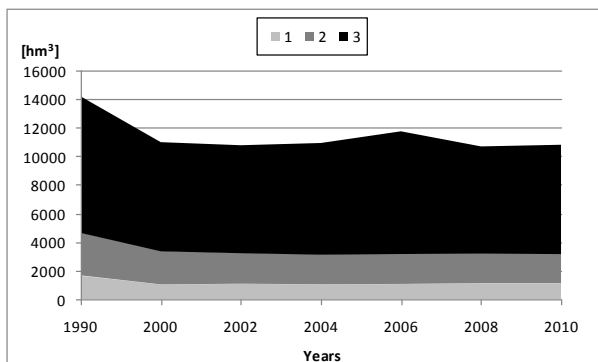


Fig 4. Water intake in Katowice Voivodeship (1990) and Silesian Voivodeship in the years 2000 – 2010. 1 – irrigation in agriculture and forestry, 2 – exploitation of the water pipe network, 3 – industry (worked out by me on the basis of data from the Central Statistical Office)

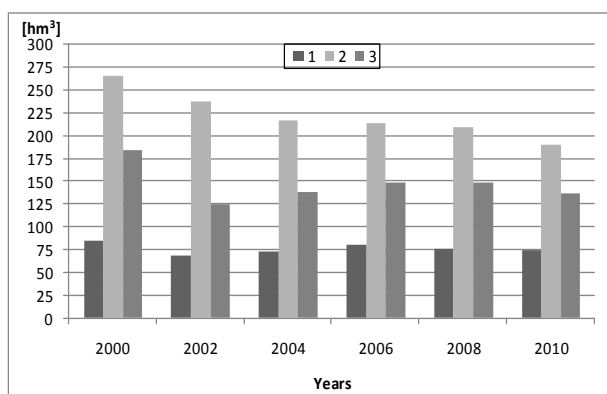


Fig 5. The use of water in Silesian Voivodeship between 2000 – 2010. 1 – irrigation in agriculture and forestry, 2 – exploitation of the water pipe network, 3 – industry (worked out by me on the basis of data from the Central Statistical Office)

For the needs of industry in 2010, 137,3 hm³ of water was used, 89,2% of which was used for production. The use of water for industry constituted over 1/3 of the overall use in the voivodeship and was 7,8% higher than in 2008 and 7,4% smaller than in 2006.

On the basis of the amount of sewage collection, the use of water can be estimated, but the process of sewage treatment shows the stage of the technological development of the region and the ecological awareness of its citizens (Absalon 2007).

Between 2000 – 2010, there was a 16% decrease in the quantity of industrial and municipal wastewater which require cleaning but which are poured away to waters or ground (fig 6). The proportion of industrial and municipal wastewater from Silesian Voivodeship in the general quantity of water requiring cleaning in Poland

was 57% and 43% respectively. About 30% of the general quantity of wastewater requiring cleaning were saline mine waters disposed by coal mining.

A characteristic feature of the structure of sewage treatment in Silesian Voivodeship was a high proportion of mechanically cleaned sewage (about 40%), especially in 1990 which was connected with the introduction of mine waters which were cleaned mechanically from coal slurry. A beneficial change in the structure of sewage treatment was the increase of the quantity of cleaned sewage.

Gradually, the quantity of municipal wastewater cleaned mechanically and biologically is decreasing in favour of sewage cleaned in sewage-farms with increased disposal of biogenes. In 2010, out of 146,3 hm³ of municipal wastewater exposed to cleaning, 84,9% was cleaned by the increased disposal of biogenes method, 14,9% biologically, and only 0,2% mechanically (in 2000 it was respectively 21%, 40%, 33% out of 2200,2 hm³). By the end of 2010, in Silesian Voivodeship there were 212 municipal sewage-farms used with the accumulative discharge capacity of 1346,0 hm³ per day, including 122 biological, 83 with increased disposal of biogenes and 7 mechanical sewage-farms.

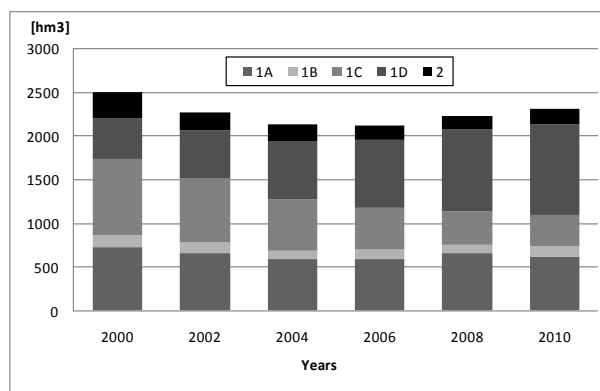


Fig 6. The treatment of industrial and municipal sewage in Silesian Voivodeship in the years 2000 – 2010. 1 – sewage cleaned: A – mechanically, B – chemically, C – biologically, D – with the increased disposal of biogenes; 2 – sewage not cleaned (on the basis of Central Statistical Office)

The percentage of the population in the voivodeship using the sewage-farms in 2010 amounted to 65,2% and was 17,8% higher in comparison to the year 2000 (fig 7). The increasing trend of the use of sewage-farms by the population during the analysed years should be noted. They were used by 11,4% of people in rural areas and 88,6% in cities.

A beneficial change in the water management is the endowment of cities with a water supply and sewage network (fig 8).

Silesian Voivodeship has a relatively small quantity of water supplies. Only a small part of the supplies can be used by the economy because the rest is very polluted. The reason for this is the atmospheric pollution, problems

with protecting the environment against the consequences of waste storage, chemical fertilizers and plant protection products, and the discharge of sewage to water basins and watercourses. Providing a sufficient quantity of water for the population, economy and industry has a vital meaning for the development of the region (Jechna 2008).

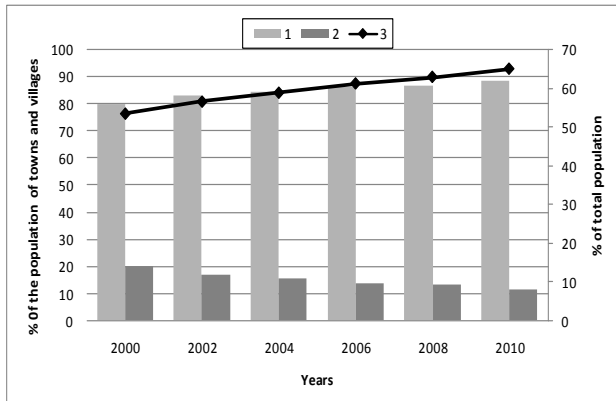


Fig 7. The population using sewage-farms in Silesian Voivodeship in the years 2000 – 2010. 1 – cities, 2 – rural areas, 3 – in general (worked out by me on the basis of data from the Central Statistical Office)

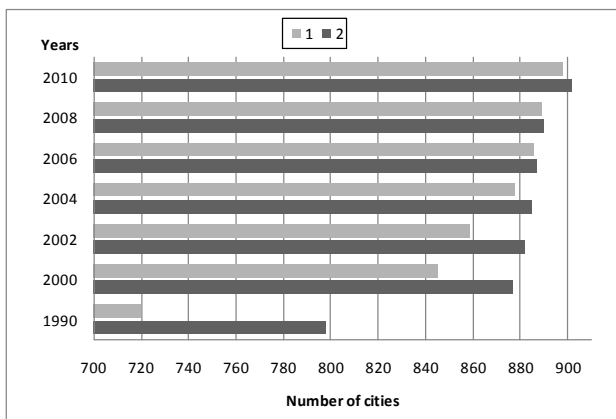


Fig 8. Cities endowed with a water supply network in Katowice Voivodeship (1990) and Silesian Voivodeship in the years 2000 – 2010. 1 – sewage network, 2 – water supply network (worked out by me on the basis of data from the Central Statistical Office)

The rivers in Silesian Voivodeship are subject to annual evaluation on the basis of the results of monitoring examination conducted by the Voivodeship Inspector of Environmental Protection in Katowice. The analysis used the data from 2008 because of the biggest number of measurement points according to which the analysis was conducted (214) situated in 162 homogenous parts of ground waters (JCWP).

Waters are classified according to the physico-chemical and biological factors, taking into consideration all the examined factors (the so called general classification). The results of the general classification of Odra and Vistula catchment in the area of Silesian Voivodeship in 2008 are presented in fig 9. The analyses show

that in 2008, there were no waters with the quality class I in Silesian Voivodeship. The waters of bad quality amount up to 56%, classes IV and III 19%.

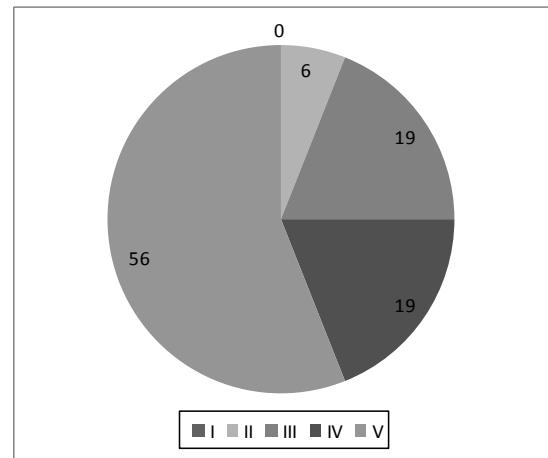


Fig 9. The joint proportional evaluation of the quality of waters in Vistula and Odra catchment in the area of Silesian Voivodeship in 2008. I – waters of very high quality, II – waters of good quality, III – waters of satisfying quality, IV – waters of non-satisfying quality V – waters of bad quality (according to the data of the Voivodeship Inspector of Environmental Protection, 2009)

The management of water in the Klodnica catchment

The water supplies of the catchment are influenced by natural factors, as well as those caused by man’s activities. Rainwater is directly disposed to rivers as a result of impermeable surfaces (roads, built up areas), which cause quick flow. The changes of flows are caused not only by precipitation, but also by disposing to rivers the mine waters from coal mines. When the resources are too small to satisfy the need for water, the water is transferred from outside the catchment. The results of the mining activities in this area are basins thanks to which the surface retention of depression of the catchment is higher (Absalon *et al.* 2010).

Klodnica catchment is densely populated. Over 950 thousand people live here. The average population density amounts to about 1100 people•km². There is a visible diversity of this rate between the upper and middle reaches of the river. In the upper part of Klodnica there are big cities – Katowice, Ruda Slaska, Swietochlowice, Bytom, Gliwice and Zabrze, where the population density is between 1700 – 4600 people/km². This rate is lower in the communes in the middle reaches of the river (Nocoń *et al.* 2006).

The analysis of the number of people was conducted in cities and communes taking up a considerably high percentage of the area of Klodnica catchment. These are: Bytom, Gliwice, Katowice, Ruda Slaska, Zabrze, Mikolow. Assuming that the arrangement of population in these cities and communes is regular, the number of population was calculated according to the factors depending on the percentage of the area of a given city in the overall area of the catchment (tab 1) In the light

of these calculations, the highest number of population is in Zabrze, and the lowest in Katowice. In all the considered cities and communes the number of population was decreasing in the years 2000 – 2010 (fig 10).

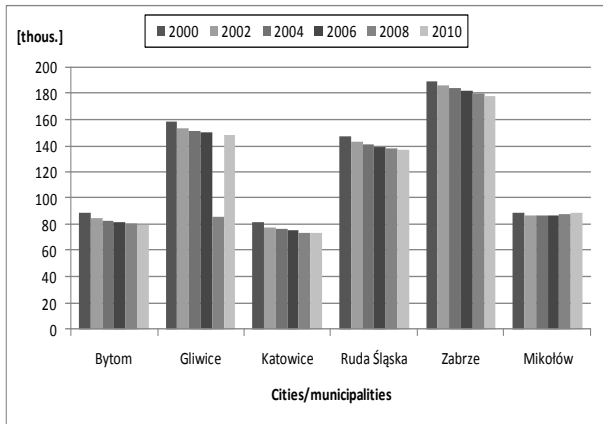


Fig 10. The population in cities and communes of Klodnica catchment in the years 2000 – 2010 network (worked out by me on the basis of data from the Central Statistical Office)

In the years 2000 – 2010 a decrease of water consumption can be noted (fig 11, 12). It is caused by the closure of many industrial plants in this area and the increase of people’s awareness about water management. The consumption of water for agriculture and forestry was registered only in Mikołów.

In Klodnica catchment there are many industrial plants with sewage disposal. In the closest neighbourhood of the river there are 33 drops through which the sewage flows directly to Klodnica river. Only 14 of them are cleaned (Absalon *et al.* 1995).

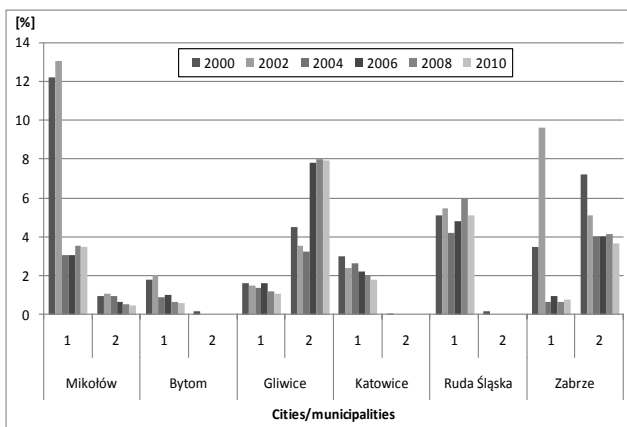


Fig 11. Water abstraction in cities and communes of Klodnica catchment in the years 2000 – 2010
1 – industry, 2 – the usage of water supplies network (worked out by me on the basis of data from the Central Statistical Office)

There are 18 sewage-farms in the analysed area of Klodnica catchment. The data from 2007 show that about 99 296 m³•24h⁻¹ of sewage was cleaned there. There were also 41 collector exits catalogued.

About 3 424 m³•d⁻¹ of contaminated water flowed through them to Klodnica catchment. 6 coal mines dispose about 3 315 m³•24h⁻¹ of sewage to surface waters of the analysed catchment (fig 13) (Działoszyńska-Wawrzkievicz 2007).

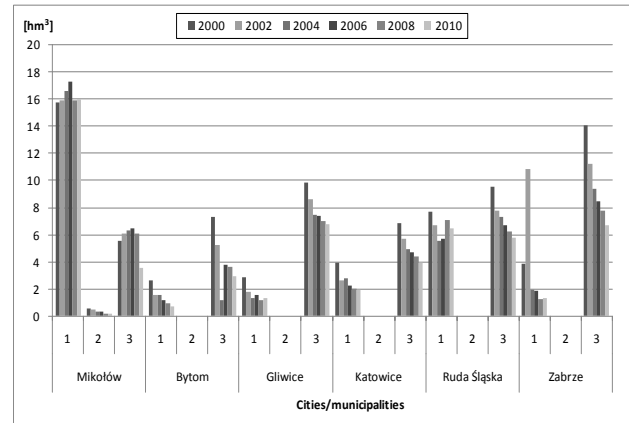


Fig 12. The consumption of water in cities and communes of Klodnica catchment in the years 2000 – 2010
1 – industry, 2 – irrigation in agriculture and forestry, 3 – the usage of water supplies network (worked out by me on the basis of data from the Central Statistical Office)

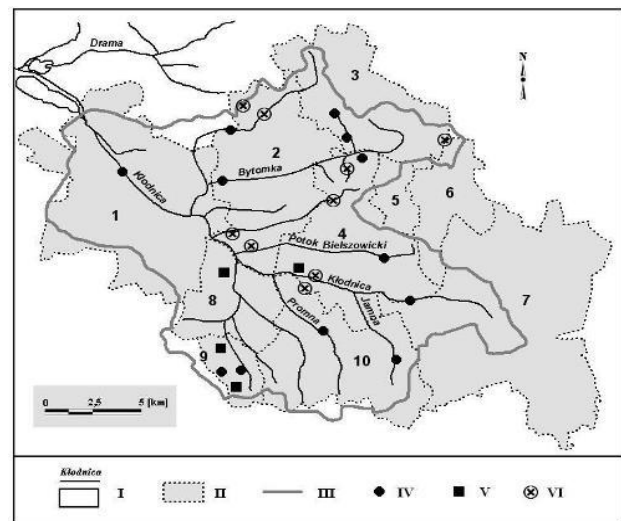


Fig 13. Sewage-farms which dispose sewage to Klodnica catchment. I – watercourses and water basins, II – the area of communes: 1 – Gliwice, 2 – Zabrze, 3 – Bytom, 4 – Ruda Śląska, 5 – Swietochlowice, 6 – Chorzow, 7 – Katowice, 8 – Gieraltowice, 9 – Ornontowice, 10 – Mikołów; III – the boundaries of Klodnica catchment, sewage-farms: IV – existing, V – planned, VI – closed by 2004 (Działoszyńska-Wawrzkievicz, 2007)

It can be noted that the quantity of contaminated water is decreasing and the disposal of biogenes is increasing in the area of cities and communes of the catchment. It is a result of strict levels of acceptable organic compounds in surface waters which were introduced by jural acts (fig 14).

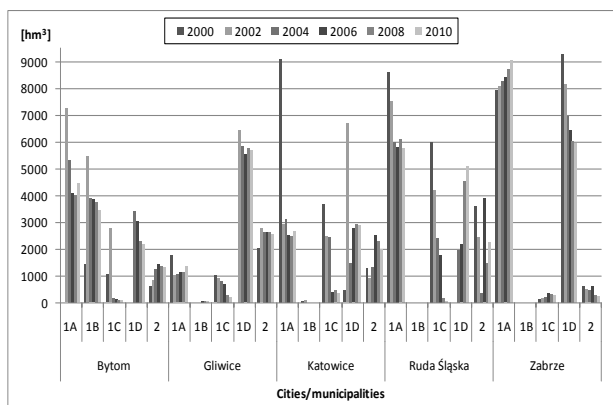


Fig 14. The cleaning of industrial and municipal sewage in cities and communes of Klodnica catchment in the years 2000 – 2010. 1 – sewage cleaned: A – mechanically, B – chemically, C – biologically, D – with increased disposal of biogenes; 2 – sewage not cleaned (worked out by me on the basis of data from the Central Statistical Office)

Gradually, the number of people using sewage-farms is increasing thanks to the development of sewage networks (fig 15).

Despite the attempts to improve the quality of water in Klodnica catchment through initiating various programmes (for example “Friendly Klodnica”), Klodnica is one of the most polluted rivers in the Silesian Voivodeship. The number of industrial plants in this area and dense population contributes to this. As a result, a lot of pollution flows to Klodnica river (Nocoń *et al.* 2006).

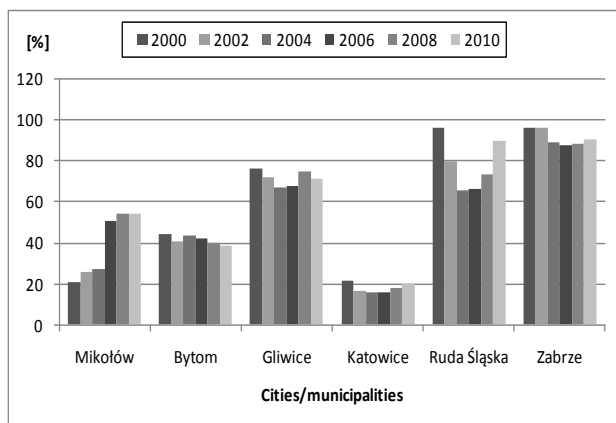


Fig 15. Number of people using sewage-farms in cities and communes of Klodnica catchment in the years 2000 – 2010 (worked out by me on the basis of data from the Central Statistical Office)

Conclusions

Water management in the first ten years of the 21st century in the area of Silesian Voivodeship was subject to many changes. These changes can be observed on the example of the cities and communes situated in the area of Klodnica catchment which encapsulates almost the whole area of the western Katowice conurbation. As a result of the decreasing number of population, the

consumption of water for the needs of national economy in this region is also decreasing. Since the year 2000, a decrease in the quantity of water used from water supplies network can be observed. The reason for that can be the increase of savings in water management caused by installing water meters in households and paying for the actual use of water (previously it was usually an all-around sum dependant on the number of people in the household or the living area of the apartment). The decrease of the water used for the needs of industry can be observed in the cities and communes of Klodnica catchment. The turn of the 20th and 21st century is a time of closure of many industrial plants in this area. The department of production is decreasing in favor of services. After joining the European Union in 2004, for many cities and communes on Poland, including Upper Silesia, there opened new opportunities thanks to European funds. The development of water supply systems and sewage networks in cities and communes was and still is possible. Since the year 2000, and especially in 2004 when a law amendment about environment protection adjusted to EU law was introduced, there was a considerable improvement in sewage treatment. More and more sewage is being cleaned, not only mechanically but also with the increased disposal of biogenes. Despite the investments in water management department, like the program of ground water protection, water supplies network development and introducing new technologies of water treatment, the ground waters in Silesian Voivodeship, including Klodnica catchment, are of even worse quality. A considerable improvement of the quality of water is expected from current investments.

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Słowa kluczowe: gospodarka wodna, województwo śląskie, zlewnia Kłodnicy, antropopresja

Abstrakt

W artykule podjęto próbę przedstawienia zmian jakie zaszły w gospodarowaniu wodą na początku XXI wieku na obszarze województwa śląskiego. Szczegółowej analizie poddano gminy znajdujące się w granicach zlewni Kłodnicy zamkniętej przekrojem Gliwice, jako przykład gospodarowania wodą na obszarze podlegającym silnej antropopresji. Zlewnia Kłodnicy jest to teren, gdzie wszystkie elementy środowiska geograficznego zostały przekształcone, lecz najbardziej widocznym zmianom uległo środowisko wodne. Wraz z początkiem XXI wieku w Polsce wprowadzono wiele zmian i to nie tylko politycznych, ale także w sektorze ekonomicznym i prawnym. Dzięki tym czynnikom pojawiły się zmiany: zużycia wody, struktury jej rozdziału na poszczególne gałęzie gospodarki oraz infrastruktury wodociągowej i kanalizacyjnej. Efektem tych zmian jest zmniejszenie zużycia wody oraz zrztu ścieków, a także unowocześnianie technologii ich oczyszczania (Absalon 2007).